11 JULY 1980 (FOUO 10/80) 1 OF 1

JPRS L/9189

11 July 1980

USSR Report

ENERGY

(FOUO 10/80)

FBIS FOREIGN BROADCAST INFORMATION SERVICE

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

For further information on report content call (703) 351-2938 (economic); 3468 (political, sociological, military); 2726 (life sciences); 2725 (physical sciences).

APPROVED FOR RELEASE: 2007/02/08: CIA-RDP82-00850R000200100020-6

JPRS L/9189

11 July 1980

USSR REPORT

ENERGY

(FOUO 10/80)

CONTENTS

ELECTRIC POWER

UDC 621. 165.001.5

ADDITIONAL POWER FROM T-175/210-130 TURBINES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 3, Mar 80 pp 2.4

[Article by Candidates of Technical Sciences D.M. Budnyatskiy and Ye. I. Benenson and engineers V.I. Vodichev and V.N. Osipenko]

[Text] Because of sharp fluctuations in the level of electrical consumption in the OES [integrated power systems] of the European part of the USSR and the large proportion of TETs [Heat and Electric Power Station] within the total make-up of these power systems, an important and real task is to use the TETs to regulate daily and weekly OES electrical load schedules and, specifically, to cover semi-peak and peak loads.

One of the ways to transfer loads to the TETs is to switch off the PVD [high-pressure heater] while preserving the maximum expenditures of live steam in the turbines. Switching off the heating plant turbine PVD's is especially effective (from a thermodynamic point of view) during the peak work period of the hot-water boilers, as long as both the electrical and the heat loads of the turbine can be simultaneously increased when directing the displaced regenerative steam bleedings into the network heaters. Moreover, all of the extra power will be generated in heat consumption, i.e., with a specific expenditure of fuel on the order of 0.15 kilograms of specific heat per kilowatt hour. As a result, the power system will realize a fuel savings proportional to the length of operation of the turbine with the PVD switched off.

The technical and economic effectiveness of switching off the PVD in T-175/T-175/210-130 turbines has been shown further on.

The possibilities of compensating for the underheating of the feed water during PVD switch-offs have been examined: the use of evaporative value reserves (heat value) of the power plant boilers relative to the maximum expenditure of live steam in the turbine. Such a possibility is workable both at block TETs (by installing turbines in a double-block arrangement with the existing boilers at an evaporative value of 420-450 tons per hour), and at TETs with cross connections with boiler evaporative value reserves, during periods of turbine repair, etc.; the installation of peak GTU [gas turbine engines] at

Table 1. Approximate Technical and Economic Indices of Replaceable Types of Power Installations

Indices	Semi-Peak 500-megawatt Power Block (in Mazut)	Peak GT-100
Proportionate capital investments, in rubles per kilowatt	110	80
Unit expenditure of fuel, in kilograms of specific heat per kilowatt hour	0.36	0.48
Closing expenditures for fuel C_t, in rubles per ton of specific heat (for coal assumed for a TETs with a T-175/210-130 turbine, and liquid or gaseous fuel assemed for replaceable power installations		35-40

the TETs and the utilization of the heat of departing GTU gases in the steam turbine's regenerative cycle, for example, by switching a special gas-water heat exchanger into the GTU cycle. The possibility exists in the given case of switching off the PVD (with appropriate compensation for feed water underheating) during the GTU operational periods, i.e., during the maximum electrical load period of the power systems--2-4 hours per day; the use of the best type of boiler for the conditions under consideration, i.e., a boiler which would basically not have evaporative value reserves relative to the maximum expenditure of live steam in the turbine (760 tons per hour), but would possess heating power reserves making it possible to lengthen its operation with a nominal expenditure of steam at a feed water temperature of 160-165 degrees C, i.e., by switching off three PVD's. In the case at hand, an analysis shows that additional capital investments in the boiler proper are required to increase its heating power Q_k above the rated, roughly by one third more than when providing the same Q_k increase because of increased steam expenditure.

Based on research carried out in conformity with the heating period (i.e., for the conditions when the problem of covering the peak load is the most acute), the following procedural prerequisites have been set.

Variations in turbines with non-detachable and detachable PVD's have resulted in an equal power effect in accordance with the size of the available capacity during the power system's maximum load period, and the amount of electrical and thermal power released during the heating season. Either the 500-megawatt specialized semi-peak power blocks or the peak GTU has been adopted as replaceable types of power installations. The type of replaceable power installation determines, according to the operational mode typical of it, the total amount of time the turbine works during the year with its PVD's disconnected. It is accepted that the additional power obtained from the TETs leads to a decrease in the power of the replaced electric power stations and the electric power generated by them. The possibility of even replacing the generation of electric power in the power system (without decreasing the capacity of the OES electricity-generating installations) has been examined as an option.

The total heating surface of the supply line preheaters and the expenditure of supply line water have been accepted as equal for variations of turbines with non-detachable and detachable PVD's.

For the installation at TETs of peak gas turbine equipment (the GT-100 has been investigated as such a one), they intend to use a combination of one GT-100 unit with a T-175/210-130 turbine. In this case the feed water will be heated up to a nominal level (230 degrees C), through the heat of the departing GTU gases, and the gas temperature for the gas-water heat exchangers will amount to about 200 degrees C.

The total cost reduction for the power installations considered and replaced has been accepted as a criterion for the economic effectiveness of the additional capacity.

The following are the basic data: the total length of time for disconnecting the PVD h_{otk} = 500 divided by 1,000 hours per year--for covering the peak loads of the power system through TETs and h_{otk} = 2,500 hours per year--for covering semi-peak loads; the climatic region is Moscow; the technical and economic indices for the replaced types of power installations (see table 1); the proportionate cost of a gas-water heat exchanger (providing the heating of feed water to a rated temperature by the departing GTU gases)--2,500 rubles per gram-calorie per year; the relative decrease in the available capacity of the GTU (when switching on the last steam turbine installation in the series)--3 percent.

An analysis shows that when the air temperatures are t_b = -(5 divided by 26) degrees C, which are typical for the operation of hot-water boilers, the growth in the capacity of the T-175/210-130 unit amounts to 11.0-9.5 megawatts, or 6.5-5.5 percent of the rated capacity of the turbine. The corresponding increases in the available capacity (net) of the turbine will be approximately one megawatt less--when using the heating power reserves of the power plant boilers, and three megawatts less--when switching the gas turbine units into the cycle of a steam turbine plant.

Table 2. Basic Technical and Economic Indices of the Additional Power of a T-175/210-130 Turbine, Obtained during the PVD Switch-Off

Indicators	Type of Turbine				
	T-175/210-130				
Method of compensating for feed water underheating	By reserves in boilers with an evaporative value of 420-450 tons per hour		By using the heat of the outgoing GTU gases	By reserves in boilers with a heating efficiency of 400 tons per hour	
Additional capital investments in TETs (for one turbine), in thousands of rubles	350		250	270*	
Type of replaced power installations	Semi-peak blocks	Peak GTU	Peak GTU	Semi-peak blocks	Peak GTU
Advisable length for obtaining additional power, in hours per year	2,500	500-1000	500-1000	2500	500-1000
Value of the net additional power (average for the period), in megawatts	9.5	8.5	6.5	9.5	8.5
Value of the additional heating plant load, in gram-calories per hour	49.7	50.6	50.6	49.7	50.6

Table 2 (cont.)

Technical and economic indices for the additional power	Proportionate capital investments, in rubles per kilowatt	37	41	38	28	32
	Proportional expenditure of fuel, in kilograms of specific heat per kilowatt hour	0.15		C	0.15	
Yearly fuel savings (for one turbine), in tons of specific heat per year		5050	1400-2800	5850-11700	5050	1400-2800
Yearly economic impact for one turbine, in thousands of rubles per year	When decreasing the capacity of replaced electric power stations and fuel expenditure on them	500	165-245	300-535	520	185-265
	When decreasing fuel expenditure at stations replacing the OES power balance	240	(-10) -70	170-405	260	10-90

*according to bibliographic entry #3

With the necessity for a maximum turbine spiking because of the PVD switch-off, the steam expelled from the steam regeneration system can be directed into the capacitor which permits a 7-8 megawatt power gain more than when the very same expenditure of steam is directed into the supply line pre-heaters.[2]

Table 2 presents the basic technical and economic indices for the additional power of the T-175/210-130 turbine obtained during the PVD switch-off and the directing of expelled steam into the supply line pre-heaters. From table 2 it follows that: 1. additional turbine power, obtained by compensating for the underheating of the feed water through the boiler unit heating power reserves, will have a unit cast of 30-40 rubles per kilowatt, and a unit fuel expenditure of 0.15 kilograms of specific heat per kilowatt hour. The corresponding yearly economic effect may amount to 265,000 rubles for one turbine unit when replacing the peak GTU (h_{otk} = 500 divided by 1000 hours per year) and 240,000-520,000 rubles when replacing the semi-peak power blocks (h_{otk} = 2500 hours per year); 2. when compensating for feed water underheating with the heat of the departing GTU gases, the unit cost for the additional power is 35-40 rubles per kilowatt hour and the unit fuel expenditure for the additional generation of electric power will be equal to zero, because in the given case the discarded GTU heat is used. The yearly economic impact of one T-175/210-130 turbine can amount to from 170,000 to 535,000 rubles in a range of values h_{otk} = 500 divided by 1000 hours per year.

The results obtained testify to the high technical and economic effectiveness of a prolonged switch-off of the PVD in T-175/210-130 turbines. Similar computed data on the effectiveness of PVD switch-offs can also be obtained for other types of heating plant turbines. Moreover, at a TETs where there are power boiler heating power reserves, it is advisable to use the additional power of the turbines for covering the semi-peak loads and at a TETs, where peak gas-turbine units will be installed, the additional power must be used for covering the peak loads.

BIBLIOGRAPHY

1. Vigdorchik, A.G.; Makarov, A.A.; Vol'fberg, D.B. "Problemy dolgosrochnogo razvitiya toplivno-energeticheskogo kompleksa" [Problems in the Long-Term Development of a Fuel Power System], TEPLOENERGETIKA, No 2, 1979, pp 2-6.

2. Terent'yev, I.K.; Budnyatskiy, D.M.; Osipenko, V.N.; and others "Puti povysheniya ekonomicheskoy effektivnosti moshchnykh teplofikatsionnykh turbin i teploelektrotsentraley" [Ways to Increase the Economic Effectiveness of Power Thermal Plant Turbines and Heat and Electric Power Plants], TEPLOENERGETIKA, No 7, 1977, pp 2.6.

3. Budnyatskiy, D.M.; Kukhtevich, I.V. "Tselesoobraznost' otklyucheniya podogrevataeley vysokogo davleniya moshchnykh teplofikatsionnykh turbin v period raboty no TETs pilovykh kotlov" [The Expediency of Switching off the High-Pressure Heaters of Power Thermal Plant Turbines during the Working Period at a TETs with Peak Boilers] in "Energeticheskoye mashinostroyeniye" [Power Machine-Building], Moscow, NIIINFORMTYAZHMASH, No 7, 1970, pp 48-49.

8524
CSO: 1822

ELECTRIC POWER

UDC 621.311.25:621.039

CONSTRUCTION FEATURES, OPERATIONAL EXPERIENCE WITH LOVIISA AES CIRCULATING PUMPS

Moscow TEPLOENERGETIKA in Russian No 4, Apr 80 pp 35-41

[Article by engineers D. Iofs, I. Kuyyala, I. Timperi, G. Shleyfer, V. Vistbakka; Candidates of Technical Sciences A.M. Prudovskiy and L.I. Turetskiy, and engineer P.N. Vorona]

[Text] The thermomechanical equipment of the Loviisa AES reactor in Finland was supplied mainly by the Soviet Union. The only exceptions to this are the GTsN's [main circulating pumps] which, based on Soviet specifications, were developed and manufactured by the Finnish firms Al'strem and Stremberg and supplied to the AES by the Finatom joint stock company to which these firms belong. The Al'strem firm developed and set up pumps with a packing water system, and Stremberg did the same for the electric motors of the pump drives with their control systems. The responsibility for the operation of all of the equipment, including the GTsN's, was given to the Soviet side (the all-union association Atomenergoeksport).

The GTsN developed by the Finnish firms has specific construction features which distinguish it from similar GTsN's of other AES's with reactors cooled by pressurized water. A description of these construction features, data on the main results of the tests of the GTsN at the producer plants and at the AES, and information about the two years of experience in operating the GTsN on the first power block of the Loviisa AES are presented below.

Technical Characteristics and Construction Features

The GTsN (figure 1) consists of two basic components--a vertical single-stage pump with shaft packing and an electric motor with a flywheel and a non-reversing device. The specifications of the GTsN are presented below.

Rated parameters of the pumped heat carrier:	
pressure..................................	12.5 MPA
temperature...............................	270 degrees C
Rated productivity............................	2 cubic meters per second

Pressure under rated conditions................	0.4 MPa
Rotation frequency............................	1475 minutes^{-1}
Power used under rated conditions (electrical)............................	1.1 megawatts
Rated parameters	
pressure................................	13.7 MPa
temperature.............................	300 degrees C
Total mass of the GTsN.........................	34,500 kg
Including the electric motor...................	17,500 kg
Total height of the GTsN (including the pressure bend)......................	6 meters
Electric motor................................	asynchronous wth short-circuited rotor windings, 6 kilovolts, computed in lengthy operation at a capacity of 1300 kilowatts

The basic components of the hydraulic part of the pump (diagonal rotor with four vanes and a diffuser with seven vanes) have been placed in the casing of the spherical molding; they have an upper lateral suction pipe and a lower pressure pipe. Such a departure from the traditional arrangement of pump pipes has permitted a decrease in the size of the casing and main flanged joint, has increased the reliability of supplying the pumps with packing water, as long as the shaft packing housing was connected to the suction side of the pump, and has simplified the configuration of the reactor's main circulating piping. At the same time such a flow organization has led to a certain lowering in the pump's efficiency which, under rated conditions, is equal to 0.79.

The shafts of the pump and electric motor have been connected with a rigid coupling into a single three-support GTsN shaft. A hydrodynamic radial bearing, placed in the pump between the hydraulic part and the shaft packing, is used in the lower support; it is lubricated and cooled with water. Ball bearings with oil lubrication are used in the two other supports located in the electric motor; the lower of them (the radial thrust one) provides the axle clamping of the GTsN shaft.

The coupling has a lengthwise joint; in it are not only lengthwise dowels, transmitting the torque, but also circular dowels, with which a significant axial force (up to 600 kN), operating on the pump shaft when there is pressure in the reactor, is transmitted to the electric motor shaft. The presence between the shaft ends of a 370 mm gap, sufficient for the groove through it for the packing units and pump bearings, is an important construction feature of the coupling and of the shafts which are connected by it. Thanks to this, the potentially most defective pump shafts can be replaced without dismantling the electric motor or disturbing the shaft alignment and it requires no more than one shift.

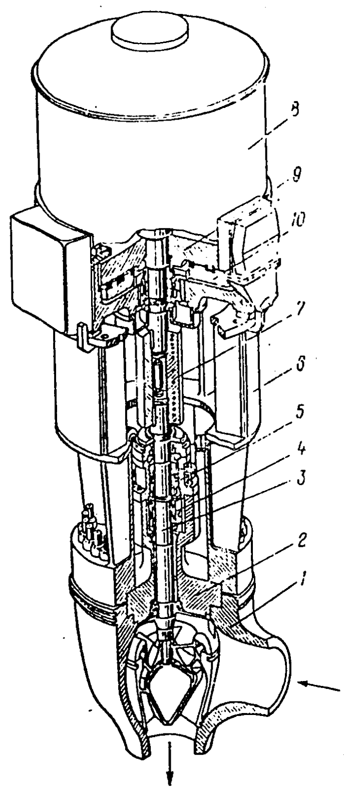

Figure 1. Over-all View of the GTsN

Key:

1. Pump casing
2. Pump cover
3. Pump shaft
4. Bearing
5. Shaft packing
6. Electric motor support
7. Coupling
8. Electric motor
9. Flywheel
10. Electromagnet

Two spiral wound-on gaskets with a graphite filling are used in packing the main flanged joint. The packing is secured with 24 bolts which are tightened with a special device with hydraulic jacks, permitting the necessary preliminary pulling out of 12 bolts simultaneously. It generally does not take more than two hours to pack the main flange.

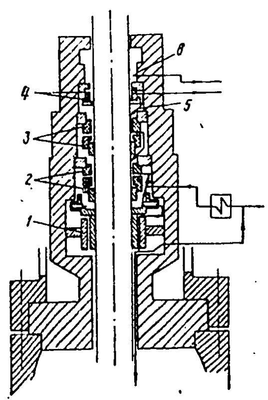

Figure 2. Diagram of the Pump Shaft Packing

Key:

1. Lower bearing
2,3. First and second stages of the hydrostatic packing
4. Mechanical packing
5. Controlled leaking
6. Flow through the end packing

The shaft packing, situated between the coupling and the lower bearing, consists of a two-stage hydrostatic packing and end mechanical packing (figure 2). The cold packing water, which has a pressure somewhat greater than the pressure in the pump, is drawn to the packing at a rate of 0.28 kg per second (one cubic meter per hour). Approximately half of this total flows through the hydrostatic packing (this is the so-called controlled flow), in which the pressure is decreased to 0.5 MPa. The mechanical packing, working under this pressure, has a very small flow--about 0.1 percent of the controlled flow. The other half of the packing water goes through the bearing to the flow part of the pump. An additional circulating bearing loop, which includes an auxiliary propeller and an external heat exchanger (figure 2) installed on the pump shaft over the bearing, is intended to increase the expenditure of water through the lower bearing. One of the most difficult jobs which generally must be done in designing a GTsN with shaft packing is the perception of the significant axial force operating on the shaft. This problem has been solved in the GTsN of the Loviisa AES with a radial thrust ball bearing and a system for its electromagnetic discharge. This system has been constructed in the following manner (figure 3): a special power-measuring device, which uses wire strain gauges, measures the active axial force on the bearing and forms a signal, fed into a regulator, which directs the current of a circular magnet located under the flywheel of the electric motor. The regulator has been built in such a way that a constant force of 35 kN acts on the bearing. As a result, out of the total directed over an axial force of 550 kN, the greater part (515 kN) is absorbed not by the bearing but by the electromagnet. The electromagnet normally feeds on a 380-volt a-c circuit. When this supply is lost, the electromagnet automatically switches over to a supply from its own system which has an accumulator battery. Besides this, the bearing is capable of temporarily (for about 100 seconds) absorbing the full axial force of 550 kN without any practical affect on machine life. All of this makes the system, receiving the axial force, sufficiently reliable.

Thanks to the electromagnetic discharge system, it has been possible not to use in the GTsN the generally-utilized thrust journal with sliding bearings, which consumes considerable power and has a complex and cumbersome lubrication system.

Special attention was paid in designing the pump to analyzing the voltages in the elements operating under pressure of the first loop. This analysis was conducted by a modern end elements method using computer programs developed by the joint stock company Finatom. In this analysis, all operational modes in which a GTsN can operate were examined. It was established that the temperature stresses are fixed for the basic pump elements operating under pressure (the casing and cover of the pump).

All of the pump elements, which are in contact with the primary heat carrier, are made of stainless steel, basically of the austenitic type. The pump casings are made of castings, to the lower part of which have also been welded cast pressure bends, and to the side suction branch pipes--forged adapters, to which, in turn, are welded the reactor's main circulating piping.

Plant Tests of the GTsN

A special experimental loop was constructed at the Al'strem firm plant in the city of Karkhul to test the GTsN by checking its working capacity and determining the specifications for various, including rated, parameters and rates for the re-pumped heat carrier. This loop, made of pipes with an outer diameter of 700 mm, 45 mm long, was designed at the joint stock company Finatom in 1969; in 1970-71 its components were manufactured mainly by plants belonging to the joint stock company; at the beginning of 1972 the loop was ready for tests of the GTsN prototype which had been manufactured by that time.

The experimental loop had a pressure support system with a steam electrically-heated volume compensator; a support system for the required water-chemical mode, including a deaerator and ion-exchange filters; a system to dissipate heat from the circulating heat carrier; a system for pumping packing water; a system for measuring, recording, and automatically controlling parameters in which they specifically hoped to use an external computer to process the recorded data on-line; and a system of automatic guards in case the parameters moved beyond acceptable levels.

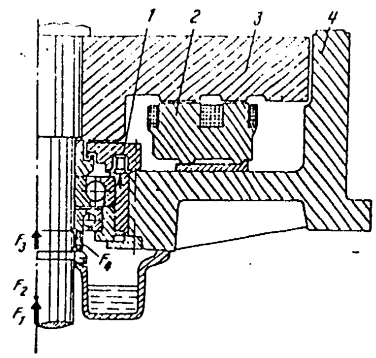

Figure 3. Diagram of the Lower Part of the Electric Motor with a Radial Thrust Bearing and Electromagnet

Key:

1. Force-measuring device
2. Electomagnet
3. Flywheel
4. Engine bed

F_1. Axial force of 615 kH, caused by the pressure in the loop and by the thrust of the pump

F_2. Weight of the rotary parts of the GTsN, equal to 65 kH

F_3. Force of 515 kH, perceptible by the electromagnet

F_4. Force of 35 kH, perceptible by the bearing

Tests of the full-scale GTsN prototype with standard electric motor were conducted on the experimental loop in the city of Karkhul during 1972-73; their total length was 1,700 hours. The operation of the pump with various rotors was checked during these tests. As a result, a rotor was selected which provided the necessary thrust for the given productivity and the Q-H characteristic of the pump (productivity-thrust) was improved--characteristic of axial and diagonal pumps, the dip in the Q-H curve shifted to the area of slight productivity, far from the pump's operating point.

Two types of shaft packing were tested. As a result, the packing described above which consists of two hydrostatic packings from the Champlain firm (Canada) and mechanical packing from the Burgman firm (FRG) was chosen for use in GTsN's supplied to AES's. Great attention was paid to improving the packing unit of the main flanged joint which resulted in the elimination of the heat carrier flow in the transitional states which was observed in the first period of plant testing. Special studies of mechanical vibrations and hydraulic pulsations were an integral part of the tests conducted. Various bearings were tested in the GTsN electric motor during this period and the construction of the stator coil was improved. As a result of the prototype testing, the reliability of the GTsN was substantially increased.

Acceptance tests of the GTsN pilot model, lasting a total of 1,300 hours, was the next work stage for the plant experimental loop. More than 40 cycles of heating and cooling in a temperature range from 50-60 to 270 degrees C were carried out during these tests. Work was also continued during this period on improving the separate pump parts in order to increase their dependability both under normal operational conditions and in emergency situations which were imitated on the testing stand.

Representatives of the firm Imatran Voyma as well as Soviet specialists participated in the majority of the GTsN tests conducted at the plant. A significant part of the success of the work on creating so complex a unit as the GTsN for the Loviisa AES was due to the fruitful cooperation of the representatives of Finnish and Soviet organizations at all stages in the creation of the GTsN, especially at the plant testing stages of the pump prototype and pilot model.

Testing and Operation of the GTsN during the Start-Up and Adjustment Work Period at the Loviisa-1 AES

A large number of tests of the GTsN and packing water system under various operational conditions, including simulations of various emergency modes, were conducted during the start-up and adjustment work period. Each GTsN worked approximately 2,000 hours during the start-up and adjustment period. The working capacity of the GTsN and packing water system under AES operational conditions was verified through the tests conducted. It was established that the consumption of the heat carrier, provided by the GTsN, was sufficient for the dependable cooling of the reactor and that the other major characteristic of the GTsN--its rundown after de-energization (the rotation of the GTsN by inertia because of the energy stored by the electric motor flywheel)--satisfies the requirements claimed for it.

It was observed during the reactor's hot breaking-in period that the power used by the GTsN was greater than on the plant testing stand, and there were two groups of pumps (three GTsN's per group), each of which had a different increase in power: if for GTsN's 1-3 (for the sake of brevity we will call them the left ones) it amounted on the average to 135 kilowatts, i.e., 12 percent, then for the right GTsN's (numbers 4-6) it reached, on the average, 210 kilowatts, i.e., almost 20 percent.

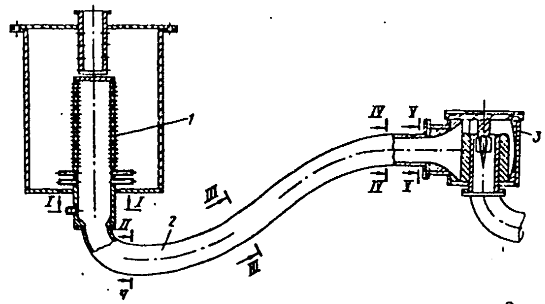

Figure 4. Experimental Plant

Key:

1. Model of the sectional conduit of the steam generator PG
2. Model of the suction conduit
3. Pump model

I-IV. Cross sections of the measurements of the speed and static pressure fields

Two GTsN's (numbers 1 and 5) were dismantled and carefully examined after completion of the hot breaking-in period. Corrosion deposits were discovered on the surfaces of the flow part of the GTsN (the rotor and diffuser) which were especially significant on the entry and exit rims of the rotor, where their thickness reached 2-3 mm. The presence of these deposits, connected, as it was later established, with the peculiarities of the water-chemical conditions in the first loop in the hot breaking-in period and with the magnetism both of the corrosion and of the metal of the rotor, diffuser, and shaft could explain some increase in the power used by the GTsN. However, there was a difference in the capacities of the left and right GTsN's. It was assumed that this difference was due to the different velocity fields in the entry sections of the left and right pumps because of the different circulating loop configurations in which the pumps of these two groups were installed. Indeed, the over-all lay-out of the first loop is such that the three left circulating loops in the scheme are mirror images of the three right loops, while the difference between them is determined by the different reciprocal arrangement of the piping connecting the steam generator with the GTsN, and the steam generator--in the left loops the steam generator axes have been turned relative to the vertical planes which are carried out through the axis of the appropriate pipes going from the steam generators to the GTsN's at 52 decrees counter clockwise, and in the right loops--at the same angle in a clockwise direction.

To check the accuracy of this hypothesis, they created at the scientific research department of Gidroproyekt [All-Union Planning, Surveying, and Scientific Research Institute imeni S. Ya. Zhuk] in Moscow an experimental plant with a model of a section of the circulating loop from the steam generator to the

GTsN, one-third actual size, also including within itself a model of the sectional conduit of the steam generator and a simplified model of the entry part of the GTsN. A diagram of the unit is presented in figure 4. Arranged in the head tank of this unit, a model of the vertically-situated sectional conduit of the steam generator had a large number of branch pipes for feeding water inside the conduit. The density of placement of these branch pipes both on the perimeter and by height has produced a pipe placement density in the conduits of the full-scale steam generator which is substantially irregular. They also considered the different water inflow speed into the conduit of the full-scale steam generator, connected with a different length, and consequently, with a different hydraulic resistance of its pipes during the selection of the distribution density of the branch pipes. In the construction of the unit they provided for the possibility of rotating the conduit relative to its axis so that during the tests the geometric characteristics of both the left and the right loops could be reproduced.

The internal shapes of the section up to the (rotor) entry rims were roughly reproduced in the pump model. The pipe model and the upper cover of the pump model were made of plexiglas which permitted the observation of the flow when the streams of liquid were dyed. Besides visual observations and flow recording, photography produced measurements of the distribution of the component velocity vectors with a three-component probe and pressure in the sections designated by the Roman numerals in figure 4.

The tests established that the distribution of speeds through the cross-section in the lower part of the sectional conduit of the steam generator was sharply irregular. Both for the right and the left loops, the velocity maximums were shifted relative to the center of the cross-section to the side opposite the section with the maximum specific expenditure of water entering through the pipe still of the steam generator. On account of this, in the pump's suction pipeline during flow rotation, immediately following the outflow from the sectional conduit, a transverse circulation develops, clearly fixed on the model and supported down to the entry into the pumps. In the pipelines of the left loops it is directed (if it follows along the flow) counter-clockwise and in the pipelines of the right loops it is clockwise (figure 5). At the entry into the pumps one can also notice some shifting of the velocity maximums in the upper part of the cross-section of the pipeline which is due to the influence of the final bend of the suction piping.

The velocity circulation in the suction pipeline noticeably influences the kinematic characteristics of the flow in front of the rotor. The point of division of the flow parts moving over the different sides from the rotor, shifts in the left pumps to the right of the horizontal axis which is accomplished through the entry branch pipe of the pump at about 60 degrees to the right ones--at roughly the same angle on the other side. During the even entry of water into the sectional conduit or during the artificial levelling of the flow before the entry into the pump chamber, the flow in the chamber is symmetrically relative to this axis.

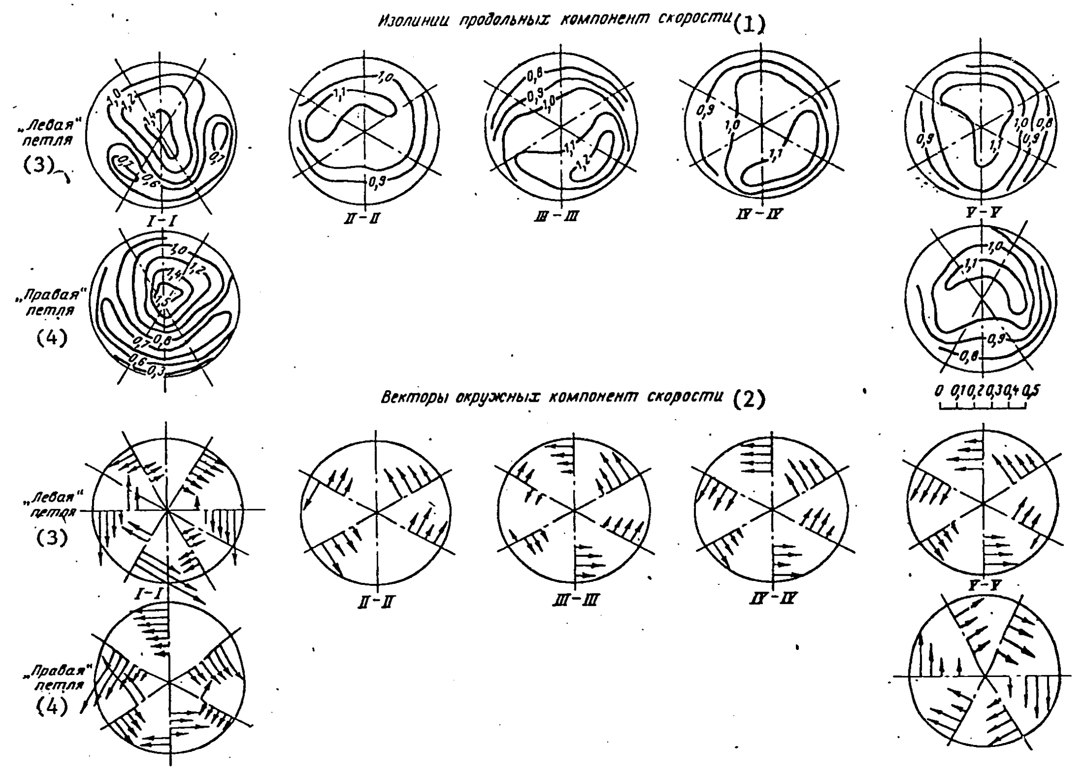

Figure 5. Distribution of Velocities in Cross-Sections of a Suction Pipe (see figure 4), Set at Average Speed (the numbers of the curves are the values of the longitudinal component velocities)

Key:
1. Isolines of the longitudinal velocity components
2. Vectors of the circumferential velocity components
3. Left loop
4. Right loop

APPROVED FOR RELEASE: 2007/02/08: CIA-RDP82-00850R000200100020-6

Because of this, the following change in the entering velocity triangles occurs. With the velocity circulation in the pipeline directed counter-clockwise, the angles of entrance into the vanes of the rotor are increased (the velocity circulation in front of the rotor is directed to the side of its rotation--clockwise). If the velocity ciruclation in the pipelines is directed clockwise, then the angles of entry to the vanes, compared to a case where there is no circulation (the plant testing stand), and decreased (the velocity circulation in front of the rotor is directed opposite to its rotation). Such a difference of entry flow angles to the rotor vanes has quite convincingly confirmed the hypothesis made earlier concerning the reasons for the difference in the characteristics of the left and right GTsN's.

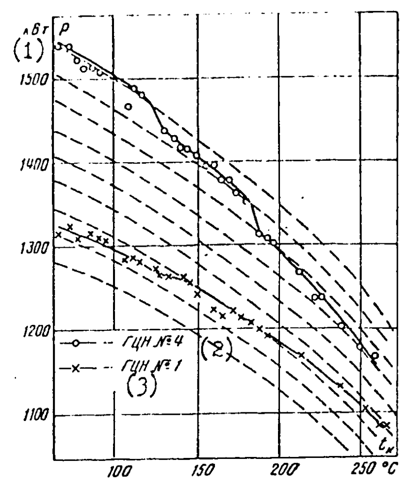

Figure 6. Change of Power of the GTsN during the Heating-Up of the First Loop after Loading with Fuel

Key:

1. Kilowatts
2. GTsN #4
3. GTsN #1

During the warming up of the first loop before the physical start-up of the reactor, when a standard water-chemical mode has been set up with the introduction of boric acid and potassium hydroxide into the primary heat carrier, the characteristics of the GTsN are substantially changed. With the heating up of the loop, the power of GTsN's #1 and 5 (which were dismantled and cleansed of corrosive deposits after the hot breaking-in period) decreased with a change of temperature, i.e., roughly proportional to the change in the density of the heat carrier, while the power of the remaining GTsN's (which were not dismantled after the hot breaking-in period and thus were "dirty") decreased significantly quicker with an increase in temperature. This is quite apparent in figure 6 which depicts the change in power as a function of the temperature of the heat carrier for two GTsN's--one "Clean one (#1) and one "dirty one (#4). In this figure the dotted lines show how the power of the GTsN must change depending on the temperature of the heat carrier. In the graph of the change in power of GTsN #4, its step change with temperatures of 120 and 180 degrees C, and with a heating of the loop under a constant temperature, is quite noticeable (figure 7). By the end of the heating-up process, the capacities of all the GTsN's became almost the same as they must be in accordance with the test stand characteristics: the power of the left GTsN's became 1-3 percent less, and the right GTsN's 1-5 percent more than the testing stand data.

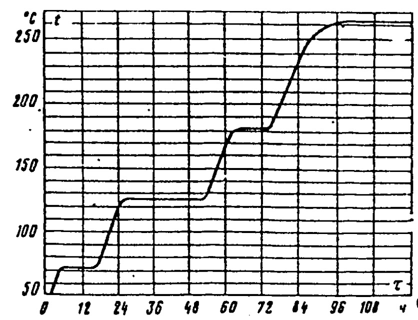

Figure 7. The Change of Temperature during the Reactor Warm-Up Period after Fuel Loading

Key:
1. Hour

An analysis of the experimental data, obtained during the hot breaking-in period, during the testing of the GTsN before the physical turn-on of the reactor and during testing at NIS Gidroproyekt, has permitted us to make the following basic conclusions:

--corrosive deposits were observed on the vanes of the rotors and diffuser during the hot breaking-in period; with the presence of these deposits, especially significant on the entry rims of the rotor vanes, the velocity circulation in the heat carrier flow in front of the GTsN considerably influenced the power used by them, apparently mainly because of the flow separation during the flow around the entry edges of the vanes;

--after washing off the corrosion products which had settled on the vanes, the influence of velocity circulation fell sharply; it just about ceased to influence the power of the pumps. Apparently, this was connected with the fact that when there were no deposits present, especially on the entry edges of the rotating vanes, there was already no flow separation during their flow-past.

The water-chemical mode, observed during the hot breaking-in period, was never repeated again during further operation of the AES, because the heat carrier will always contain an amount of potassium hydroxide such that the pH of the heat carrier under "hot" conditions will be within the limits of 9-10 irrespective of the concentration of boric acid. This consideration has permitted us during the AES starting-up period to conclude that the alkaline mode, installed for the first time in the first loop of the Loviisa-1 AES before the physical turn-on stage and introduced for the purpose of washing out the deposits produced during the hot breaking-in period will, during the entire operation of the AES, prevent the appearance on the GTsN elements of deposits which would impact on the power used by them. This conclusion has been fully confirmed by the experience of the two-year operation of the first energy block of the Loviisa AES.

The Work of the GTsN during the Two Years of the Operation of the Loviisa-1 AES

During the two years of operation the GTsN's worked very reliably--there was not one case of a forced shutdown of the AES energy block because of defects or the inability of the GTsN to work. Some insignificant defects in the bolted joints of some of the parts were discovered during the inspection of the GTsN in the period of the first and second loadings of fuel in the pumps. The appropriate parts of these joints were repaired or rebuilt.

Conclusions

The Finnish machine building companies in a relatively short period of time have developed and set up at the Loviisa AES the main circulating pump with shaft packing which has definite advantages over similar pumps installed at other AES's with reactors cooled by pressurized water. One of the principal advantages is the possibility of replacing the potentially most defective units (bearing and shaft packing of the pump) within several hours without dismantling the GTsN as a whole, and also the use of ball bearings together with an original system of electromagnetic discharging from the axial force, instead of the radial-thrust sliding bearings used in similar GTsN's.

The two years of operational experience have confirmed the working ability and reliability of the GTsN at the Loviisa AES.

8524
CSO: 1822

ELECTRIC POWER

BRIEFS

POWER TRANSMISSION LINES--The 500-kilovolt a-c power transmission lines are presently the basic intersystem communications in the USSR. Lines with a 750-kilovolt capacity have been put into operation, e.g., the Trans-Ukrainian line from the Donbass to the Western Ukrainian substation and further on to the Al'bertirsh substation in Hungary and the Leningrad-Moscow line. A 1150-kilovolt VL [overhead line], 325 kilometers long, is being built to handle this new voltage level. The a-c lines are intended for the mass carrying of electric power. As long ago as 1964, the first 800-kilovolt (±400 kilovolt) a-c power transmission line in the world--the Volzhskaya GES imeni 22d c"ezda KPSS-Donbass line, about 500 kilometers long with a carrying capacity of 750 megawatts--was constructed. Based on the experience of its construction and operation, they began the construction of the Ekibastuz (North Kazakhstan)-Center a-c special purpose power transmission line. The line is 2,400 kilometers long, with a voltage of 1,500 kilovolts (±750 kilovolts), and a carrying capacity of 6 million kilowatts. The intention is to transmit along it about 40 terawatt hours of electric power per year into the central regions of the country. An even greater a-c voltage (2,000-2,500 kilovolts) is required for the mass transmission of electric power from the Siberian electric power stations. One such line would permit the transfer into the European part of the country of about 250 terawatt hours of electric power which is equivalent to 160 million tons of Kansko-Achinskiy coal. [Excerpts] [Moscow TEPLOENERGETIKA No 4, Apr 80 pp 4-5] 8524

CSO: 1822

FUELS

UDC: 662.664 (-925.16)

AVAILABILITY OF COKING COAL ALONG THE BAM

Moscow SOVETSKAYA GEOLOGIYA in Russian No 3, Mar 80 pp 38-43

[Article by A. G. Portnov (VNIGRIugol'); V. F. Cherepovskiy (USSR Ministry of Geology); I. V. Pereyaslavskiy and V. S. Checketkin (Chita Territorial Geological Administration)]

[Text] The construction of the Baykal-Amur Mainline serves as a powerful stimulus to the development of the productive forces of the northern Trans-Baykal Region, where the Udokanskiye copper deposits are located and also where significant reserves of iron ore have been discovered. The Udokanskiy territorial-industrial complex is being projected on this basis. In connection with this project, it is necessary to draw upon large deposits of energy coal and coking coal inasmuch as the only known deposit, the Chitkanda deposit, because of its small quantity of explored reserves, cannot be considered the hoped-for fuel-energy base of the future complex, and industrial amounts of coking coal have been unknown here until recently.

Unquestionable interest has been aroused in recent years by new materials on the coal potential of the territory lying to the north of the BAM route and in the southern spurs of the Kodar Ridge (Fig. 1). Coal was discovered in this region in the 1930's and 1940's, and in the 1950's a small amount of exploration was conducted in certain areas, but the scale of the coal potential was not established. All of the manifestations correlate to small (from hundredths to tens of square kilometers), disconnected developmental fields of Jurassic deposits, which have been given the name Kodar Coal Region by the authors. The largest of these fields is the Apsat (around 100 km^2).

The analysis of materials from survey and exploration work permitted one of the authors of the present article (A. G. Portnov, 1969) to make a conclusion about the uninterrupted character of the distribution of the coal-bearing strata within the borders of the Apsat field, to unite the known manifestations of coal into a single deposit, to estimate the coal reserve at 1.1 billion tons, and to make the deposit a first-rank target for geological exploration.

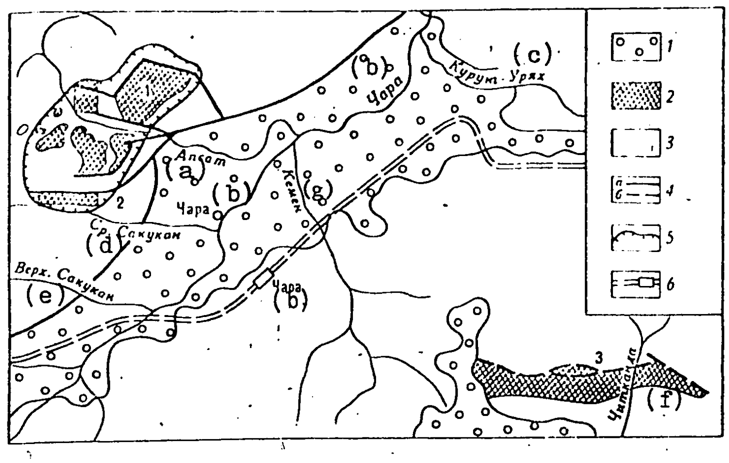

Figure 1. Diagram of the Distribution of Jurassic Coal-bearing Deposits of Northern Trans-Baykal in the BAM Region.

Key:

(a) Apsat
(b) Chara
(c) Kurun'-Uryakh
(d) Middle Sakukan
(e) Upper Sakukan
(f) Chitkanda
(g) Kemen

1. Cenozoic deposits
2. Jurassic coal-bearing deposits
3. Archean and Proterozoic formations
4. Tectonic disturbances (a - established, b - conjectural)
5. Contour of the Kodar coal-bearing region
6. BAM route

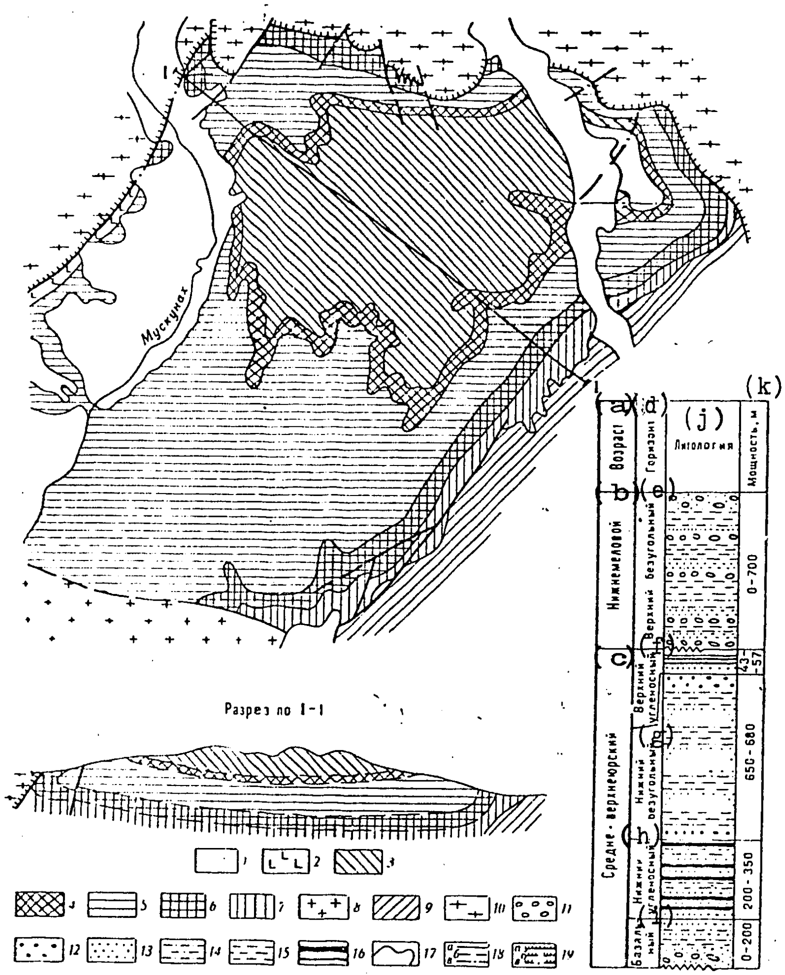

Figure 2. Diagrammatic Geological Map of the Apsat Field (according to materials of the Chita TGU, with additions).

Key:

1. Quaternary deposits
2. Diabase dikes and sills probably Upper Tertiary-Quaternary
3. Lower Cretaceous deposits (upper non-coal level)

4-7. Middle and Upper Jurassic deposits

5. Lower non-coal level
6. Lower coal-bearing level
7. Basal level
8. Granites and granodiorites
9. Metamorphic sandstone, gneisses, and schists
10. Archean formations--crystalline schists, gneisses, and granite-gneisses

Figure 2. Diagrammatic Geological Map of the Apsat Field--Continued.

Key (continued):

11. Conglomerates
12. Gravellites
13. Sandstones
14. Siltstones
15. Argillites
16. Coal strata
17. Stratigraphic boundaries

18-19. Fault disturbances (a-established, b-conjectured, and c-under Quaternary deposits)

18. Faults and fault-shifts
19. Fault-thrusts

(a) Geological period
(b) Lower Cretaceous
(c) Middle and Upper Jurassic
(d) Levels
(e) Upper non-coal
(f) Upper coal-bearing
(g) Lower non-coal
(h) Lower coal-bearing
(i) Basal
(j) Lithology
(k) Thickness in meters

As the result of search work conducted from 1976 to 1978 by the Chita Territorial Geological Administration (TGU), the hypotheses were confirmed as to the continuity of coal distribution around the area. This work also refined the representations of the tectonic structure, the quantity and bedding positions of the coal strata, the quality of the coal. Prospects for the field were significantly expanded.

The Apsat coal field is located in the territory of Kalarskiy Rayon of Chitinskaya Oblast, to the northwest of the rayon center, the town of Chara, with which it is tied by a dirt road. The distance from the field to the future Chara railroad station is 40 km. The field lies in the basin of the Apsat River and is transected in submeridional directions by its tributaries, the Byyiki, the Sredniy, and the Muskumakh. Characteristic for the region is a sharply broken alpine-type relief with relative elevations of from 200 to 600 or 700 m.

The field is composed of continental deposits, primarily disintegrated rock formations (75 to 80 percent sandstones, gravellites, and conglomerates) which are bedded on an eroded surface of Archean and Proterozoic formations and which include strata and lenses of coal (Fig. 2). In the opinion of Ch. M. Kolesnikov,[1] the rock is of mid-Jurassic age and is comparable with the Durayskata suite of the Yuzhno-Yakutskiy Basin. V. S. Shul'gina[3] puts the coal-bearing part of the cross-section in the middle and upper Jurassic, but also--lying above with erosion and nonconformity with the non-coal-bearing thickness--to the lower Crtaceous which, evidently, corresponds more to reality.

With respect to structure, the field has a rectangular syncline folding, almost everywhere bounded by faults (see Fig. 2). Near the breaks in the rock, the coal layers have a sharp (60-80°) drop toward the center of the syncline and, in secti-ns where Archean crystalline formations have pushed into the coal strata (the northern and western parts of the field), their bedding is vertical or overturned. In the central part of the syncline it becomes more even and the angle of drop decreases to 5-15° and, more rarely, to 20°. Such bedding character of the coal layer permits the assumption of a flattening-out of the coal strata and intervening rock at the depth shown in the geological cross-section (see Fig. 2). In the northern and southern parts of the field are found a series of discontinuities of the fault-slide type with amplitude of displacement of 10-15 to 100-130 m, cutting the lower coal level into separate blocks.

The Apsat field, like other fields of the Kodar Coal Region, is situated at the convergence of two large tectonic structures--the old Siberian Platform and the Stanovoye anticlinal uplift, which together with other indicators provides a basis for putting it into the Perikratonnoy Group of N. I. Pogrebnov's tectonic classifications.[2] The accumulation of coal-bearing sedimentaries is related by the author to the regional compensating downwarp of the southern borders of the Siberian Platform, which has led to the origin of such basins as the Kansko-Achinskiy (eastern part), the Irkutskiy, and the Yuzhno-Yakutskiy. The downwarp has occurred in the Upper Triassic-Jurassic (and possibly also in the Lower Lower Cretaceous) Periods. The territory covered by the processes of coal formation has apparently exceeded the present area of the field and has included coal areas located to the east of the latter.

On the border of the Upper Jurassic and Lower Cretaceous, relatively weak tectonic movements have led to the rupture in the sedimentary formation and to partial erosion of Jurassic deposits, which has been expressed in discontinuity in the bedding of the Lower Cretaceous deposits on the Jurassic. In the Post-Lower-Cretaceous Period, when the intensive tangential movements took place on the Asian Continent, the coal-bearing deposits probably were crumpled in relatively gently sloping folds. The contemporary contours and structural forms of the Apsat and of other coal-bearing areas of the region, undoubtedly arose in the process of Cenozoic tectonic and magmatic activity which covered a wide territory from the western edges of Lake Baykal to the Aldan Shield. At that time, the single coal-bearing area was uplifted to a height of 200 m above the level of the Chara Cenozoic trough and was broken up into separate blocks which underwent intensive denudation, as a result of which at the present time only the most submerged of them have been preserved. With this stage of tectonic activity, evidently, are tied the transformations of fault-defined blocks into thrusts, along the planes of which, Archean formations were pushed into the coal-bearing sedimentaries, and also local effusions of magma, which had formed diabase dikes and sills on the western boundaries of the field.

Industrial accumulations of the coal in the field differ in the lower and upper coal-bearing levels (see Fig. 2), in that the overwhelming quantity of coal reserves lie with the former. Maximal coal saturation of the lower level is noted on the northern, eastern, and southeastern flanks, where from 3 to 14 coal strata can be worked. The calculated thickness of the strata everywhere exceeds 10 m, reaching 43-67 m in individual instances (with the thickness of individual strata 11-19 m), and the coefficient of workable coal-bearing changes from 4 to 37 percent. In the west and southwest directions the presence of coal in a level gradually decreases because of thinning down and tapering off of the coal stratum.

The upper coal-bearing level contains from 1 to 5 workable strata with calculated thicknesses of 5-13 m, which, in contrast to the strata of the lower level, are characterized by a very complex structure. The coefficient of industrial coal at this level changes from 8 to 32 percent.

The quality of coal in the field has been established by tests taken from the zone of oxidation, and therefore it is not possible to give definite conclusions about its composition by grade of coal. Macroscopically, the coal of the lower level represents typical durain-clarain and is formed by interstratification of semibrilliant, more rarely semidull, lithotypes with thinner streaks of brilliant vitrinite coal. In the western and southwestern directions, parallel to the decrease in thickness of the coal strata, is seen an increase in the vitrinite component in the coal. The petrographic composition of the coal of the lower level comprises (in percent): vitrinite 60-87, semivitrinite 1-15, fusainite 2-16, and leiptinite up to 1. The basic indicators of the coal quality are as follows (in percent): analytical moisture 0.6 to 3.0, more often 0.8 to 1.2, ash 7-18, often less than 12, volatiles 18-30, often 22-26, and carbon content 85-90. The combustion temperature of a fuel mass (in a test vessel) was 7600-8700 kcal/ig, and the coke residuum had an adherent, caked and, more rarely, fused character. In certain tests, the thickness of the plastic layer reached 13-18 mm. The available data permit the designation of coal from the lower level at grades KZh and K and to arrive at a fairly well-founded proposition that in an unoxidized state it is a good raw material for making metallurgical coke.

The upper level is characterized by significantly higher ash (10-40 percent, often more than 20 percent), a rise in volatiles (27-33 percent), less carbon content (77-87 percent), and the coke residuum has a powdery or caking characteristic. Presumably, the coal is grade GZh and Zh and, apparently, can be utilized as a basic energy raw material.

The geological reserves of the Apsat field at the present are estimated at 1.5 billion metric tons. Two coal bearing layers with thick coal strata have been established. Practically all of the reserves are concentrated at the lower level. This is an especially hypothetical estimate which is supported by insignificant factual data. Unfortunately, the rate of exploratory work at this field is insufficient to permit at the present time a conclusive estimate of this important area as a field with vitally scarce coking coals, located on the BAM route.

Available data show that in the northern Trans-Baykal there is a new coal-bearing region with significant reserves of technological and energy coal. Parallel with its very advantageous geographical position, it serves as a very favorable prospect for industrial utilization in the nearest term. From this, it follows that it is necessary to complete soon the exploratory-evaluative work and, first of all, to explain in depth the character of the coal content and the conditions of the bedding of the coal strata, and to determine the grades and quality of the unoxidized coal. For the solution of these tasks, upon which much of the future of the field depends (pay-off, plant capacity, and coal utilization, etc.), it is necessary in the late stages of exploration to drill several boreholes to a depth of 1000-1200 m, having put them primarily in the eastern half of the area under study.

The study of other coal-bearing areas of the Kodar Region should be started, in particular the Middle Sakukan field where, owing to the general-geological picture, the character of bedding of coal-bearing strata is more even.

REFERENCES

1. Kolesnikov, Ch. M. "Continental Mesozoic Stratigraphy of the Trans-Baykal" in "Stratigrafiya i paleontologiya mezozoyskikh i kaynozoyskikh otlozheniy Vostochnoy Sibiri i Dal'nego Vostoka" [Stratigraphy and Paleontology of Mesozoic and Cenozoic Deposits in Eastern Siberia and the Far East], Moscow-Leningrad, Nauka, 1964, pp 5-138.

2. Pogrebnov, N. I. "Tectonic Classification of Coal Basins and Deposits of the USSR" in "Tektonika ugol'nykh basseynov i mestorozhdeniy SSSR" [The Tectonics of Coal Basins and Deposits of the USSR], Moscow, Nedra, 1976, pp 58-71.

3. Shul'gina, V. S. "Geology of the Mesozoic Coal-bearing Deposits of the Kodar-Udokan Region," Thesis Report, Second Scientific Conference, Geological Section imeni V. A. Obruchev of the Trans-Baykal Division of the USSR Geographical Society, Chita, 1965, pp 27-30

9645
CSO: 1822 END